

Electromagnetic Induction Survey of the Mississippi River in Cleveland, Mississippi

By Joseph B. Dunbar and Maureen K. Corcoran

PURPOSE: This study was conducted in support of Mississippi State University's (MSU's) research; the project was sponsored by Department of Homeland Security's (DHS's) Southeastern Region Research Initiative (SERRI). This technical note was published by the U.S. Army Engineer Research and Development Center-Geotechnical and Structures Laboratory (ERDC-GSL) through the Flood and Coastal Storm Damage Reduction Program under the Remote Sensing and Monitoring focus area.

BACKGROUND: An electromagnetic (EM) induction survey was conducted along a portion of the unprotected side of the Mississippi River levee located approximately 34 km northwest of Cleveland, MS, during 19-21 October 2010 (Figure 1). The results of this survey will be used to calibrate airborne synthetic aperture radar imagery for soil type and prediction algorithms for shallow slides in levees and locating sand boils along the levee toe.



Figure 1. Test site location.



Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE AUG 2014		2. REPORT TYPE		3. DATES COVERED 00-00-2014 to 00-00-2014	
4. TITLE AND SUBTITLE Electromagnetic Induction Survey of the Mississippi River in Cleveland, Mississippi				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Engineer Research and Development Center,Vicksburg,MS,39180-				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 10	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

PRINCIPLES OF ELECTROMAGNETIC SURVEYING: EM induction surveying is used to measure the apparent electrical conductivity (inverse of electrical resistivity) of subsurface materials. Electrical conductivity is a measure of the degree to which the soil conducts an electrical current and can be used to infer the extent and type of geological materials or buried materials. Major factors influencing the conductivity measurement are the amount of pore fluid present, the salinity of the pore fluid, the presence of conductive minerals, and the amount of fracturing present within the soil or bedrock.

The instrumentation used to measure soil conductivity consists of a transmitter coil (Tx) and a receiver coil (Rx) separated by a fixed distance. An alternating current is passed through the Tx coil, generating a primary time varying magnetic field. This primary field induces eddy currents in subsurface conductive materials. The induced eddy currents are the source of a secondary magnetic field that is detected by the Rx coil along with the primary field.

Two components of the induced magnetic field are measured by the EM system. The first is the quadrature phase, sometimes referred to as the out-of-phase or imaginary component. Apparent ground terrain conductivity is determined from the quadrature component. Disturbances in the subsurface caused by compaction, in-filled abandoned channels, soil removal and fill activities, buried objects, or voids may produce conductivity readings different from background values, thus indicating anomalous areas. The second phase is the in-phase component. The in-phase component is sensitive to metallic objects, and therefore, is useful when looking for buried metal such as metal rails, rebar, or electrical wires.

SURVEY METHODS: An EM survey was conducted along a 1.8-km-long stretch of levee as shown in Figures 1 and 2. A Geonics Ltd. EM38-MK2 terrain conductivity meter, as shown in Figures 3 and 4, was used with Tx-Rx coils set at fixed distances of 1.0 m and operated in the vertical dipole mode. This allowed for a depth of investigation of approximately 1.5 m. The cart-mounted instrument was slowly towed at a height of approximately 20 to 30 cm above the ground surface along each profile line (Figure 4). The EM38 was set to a sampling rate of five readings per second, which equated to a reading being collected approximately every 20 cm along each survey line. The EM data, along with positional information obtained from a global positioning system (GPS), were collected and stored on a hand-held personal computer.

The survey was conducted between the center line of the crest and the toe of the riverside slope of the levee. Survey lines were oriented parallel to the center line of the levee crest. Pin flags were placed approximately halfway between and at the end of each survey line to aid the vehicle operator to stay on course. With the exception of the area between sta 460 and sta 470, survey lines were located along the crest, located along the crest edge, and spaced 8 m apart thereafter. Between sta 460 and sta 470, survey lines were located along the center line of the crest, the crest edge, and then spaced 2 m apart down the levee slope. An additional survey line was also run approximately 8 m from the crest on the protected levee slope between sta 500 and the western end of the survey line.

SURVEY RESULTS: The EM data are presented as conductivity contour maps. The maps are intended to show lateral changes in conductivity values related to geological and buried features within the upper 1.5 m. Figures 5 through 12 show the conductivity results for the surveyed area. Conductivity values range between -111.4 and 103.0 mS/m with a mean value of 42.8 mS/m.

The conductivity contour plots indicate that the western portion of the levee exhibits relatively higher conductivity values than the eastern portion of the survey area. Also, relatively high conductivity values are associated with the clay-gravel road that runs along the levee crest.

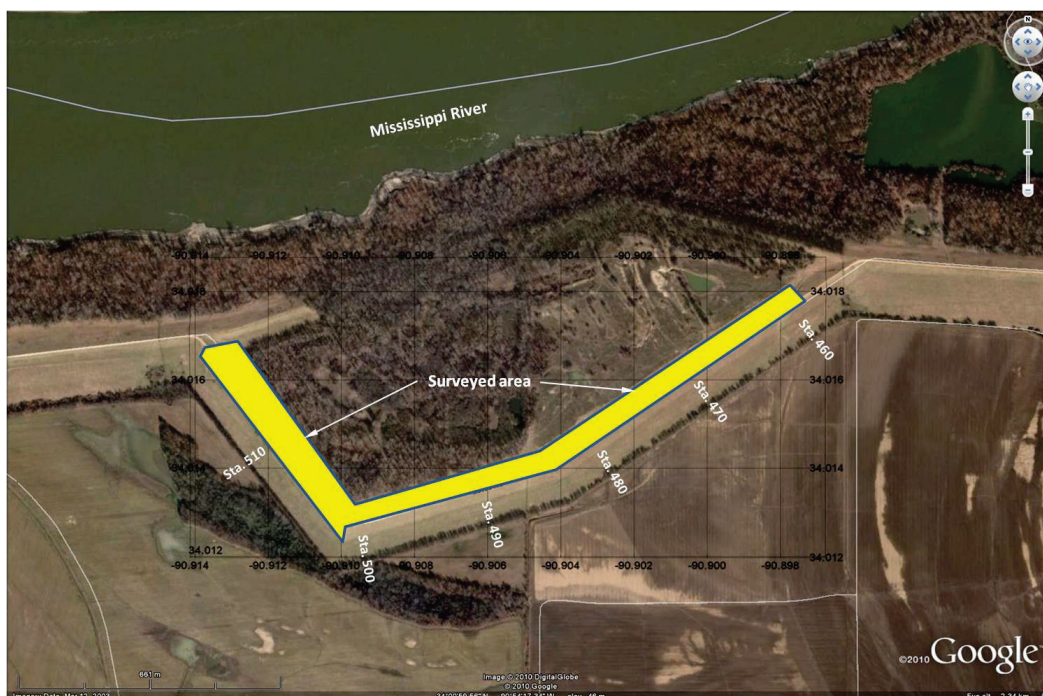


Figure 2. Location of area surveyed.



Figure 3. Geonics EM38-MK2 terrain conductivity meter.

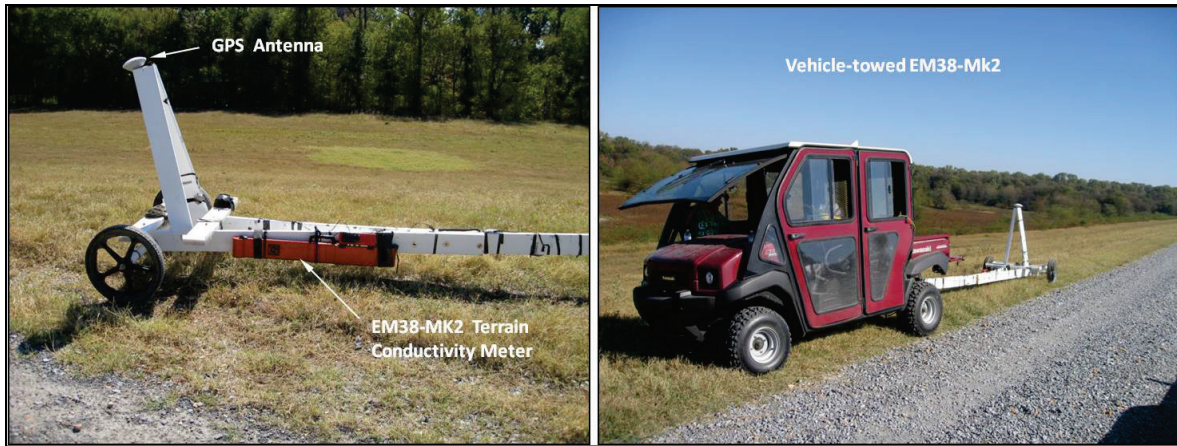


Figure 4. EM38-MK2 Terrain conductivity meter mounted on vehicle-towed cart.

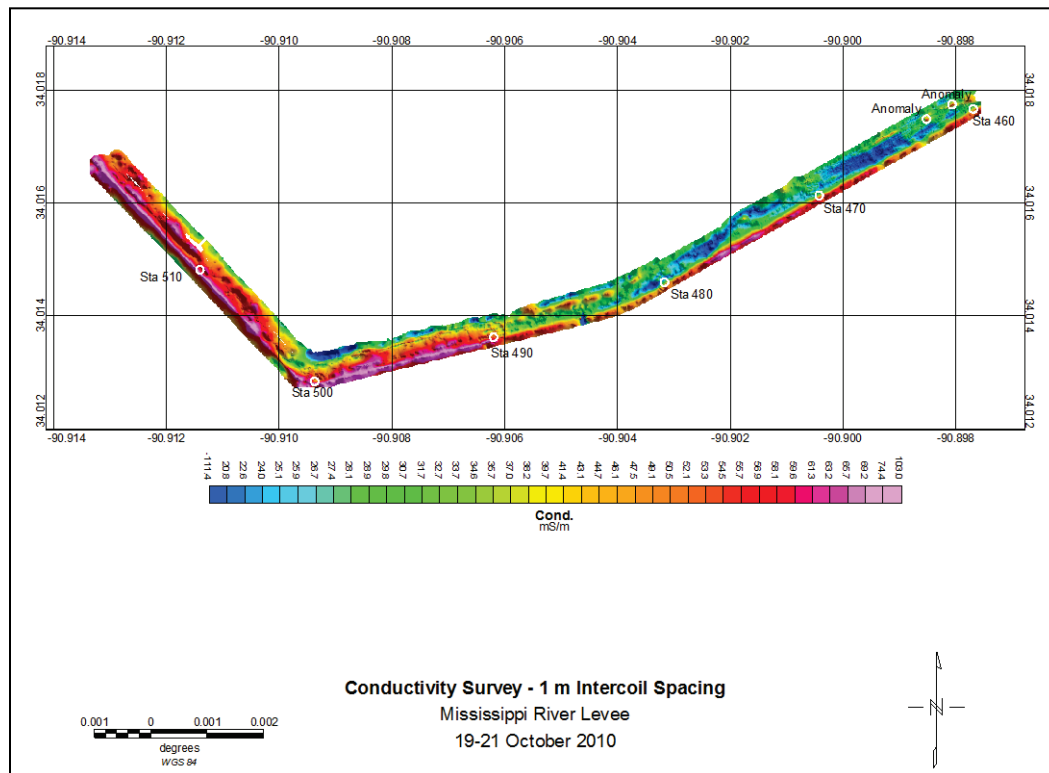


Figure 5. EM38 conductivity survey results, Mississippi River levee, Cleveland, MS.



Figure 6. EM38 conductivity survey results overlaid on Google Earth imagery, Mississippi River levee, Cleveland, MS.

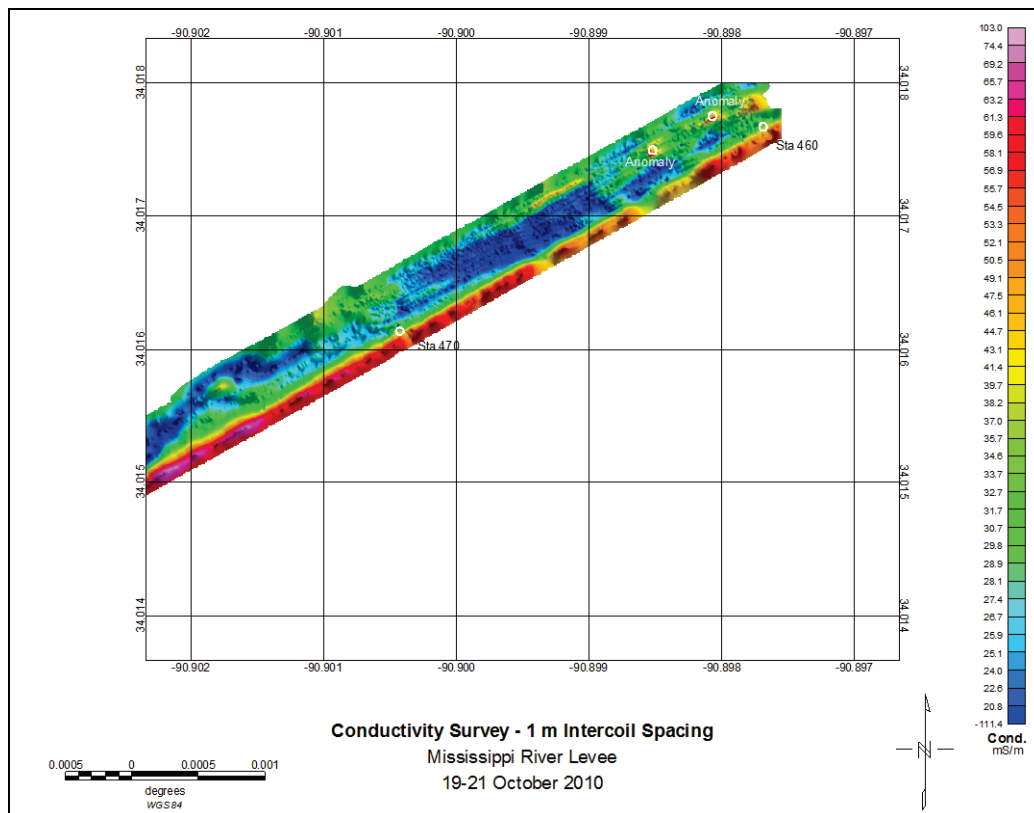


Figure 7. EM38 conductivity survey results, eastern portion, Mississippi River levee, Cleveland, MS.

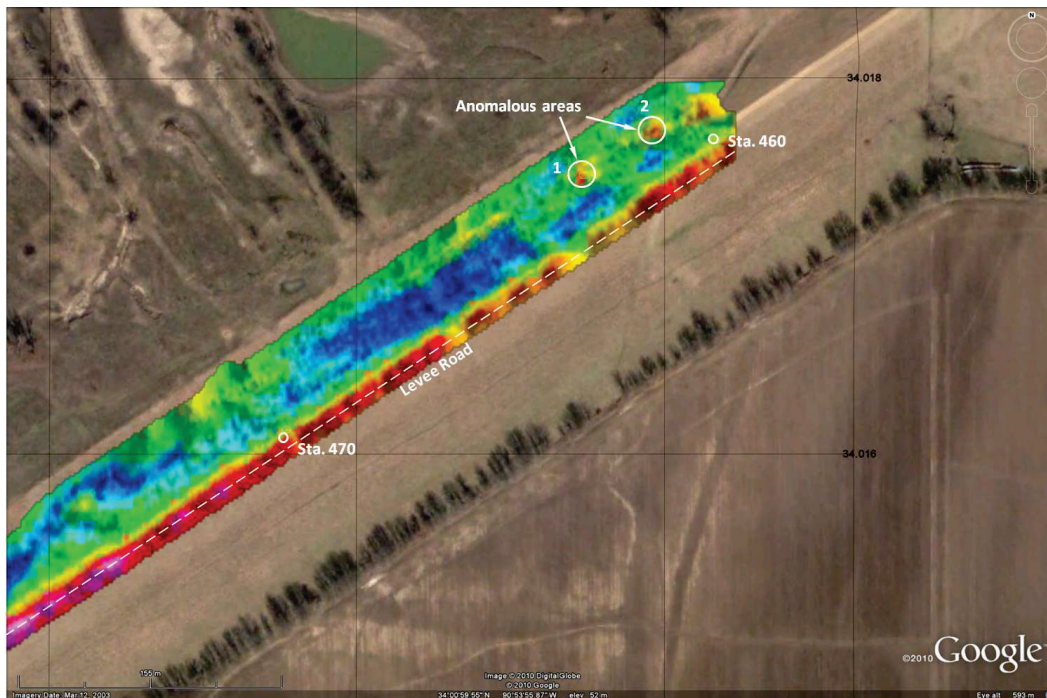


Figure 8. EM38 conductivity survey results, eastern portion, overlaid on Google Earth imagery, Mississippi River levee, Cleveland, MS.

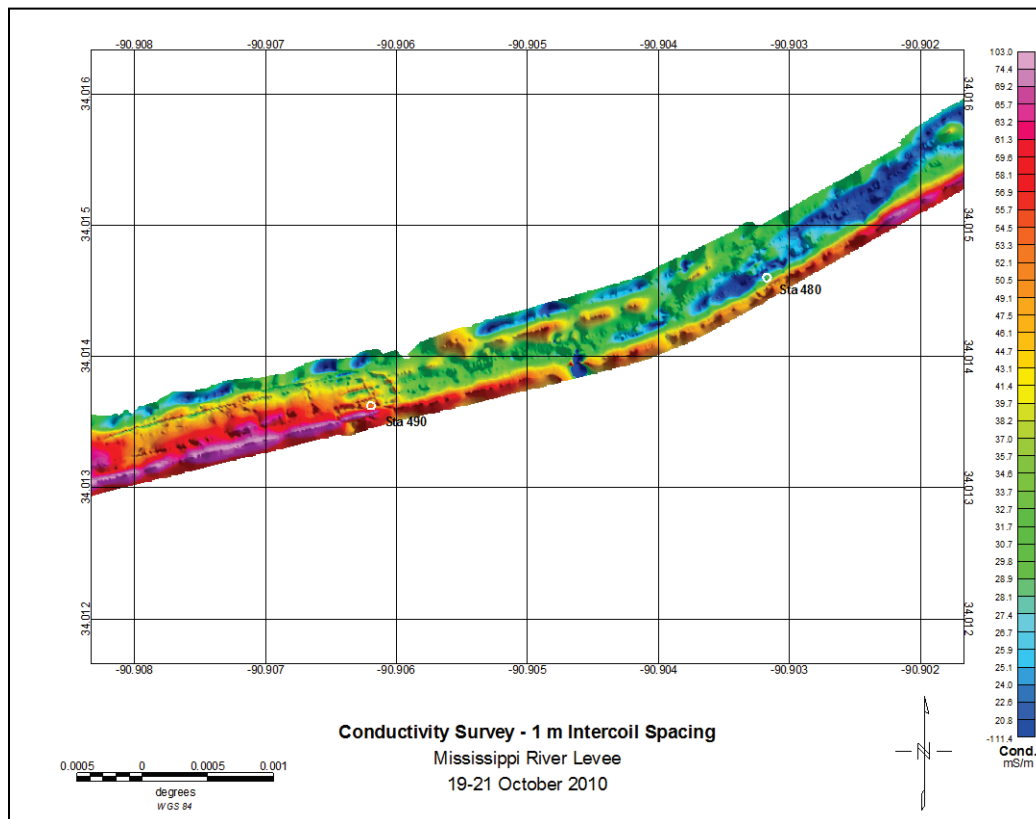


Figure 9. EM38 conductivity survey results, central portion, Mississippi River levee, Cleveland, MS.

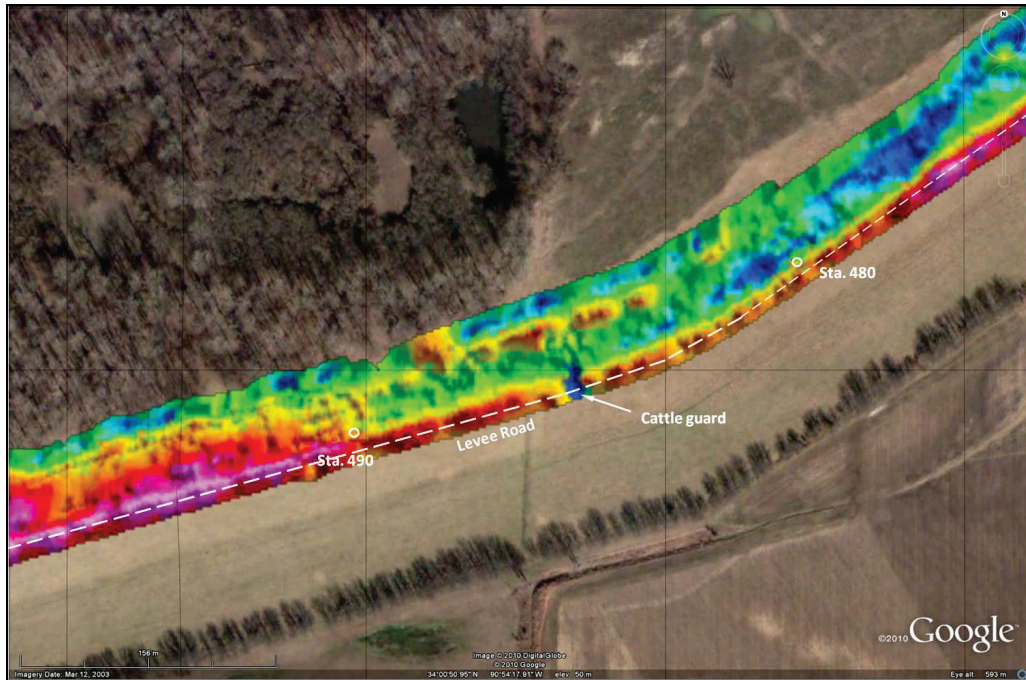


Figure 10. EM38 conductivity survey results, central portion, overlaid on Google Earth imagery, Mississippi River levee, Cleveland, MS.

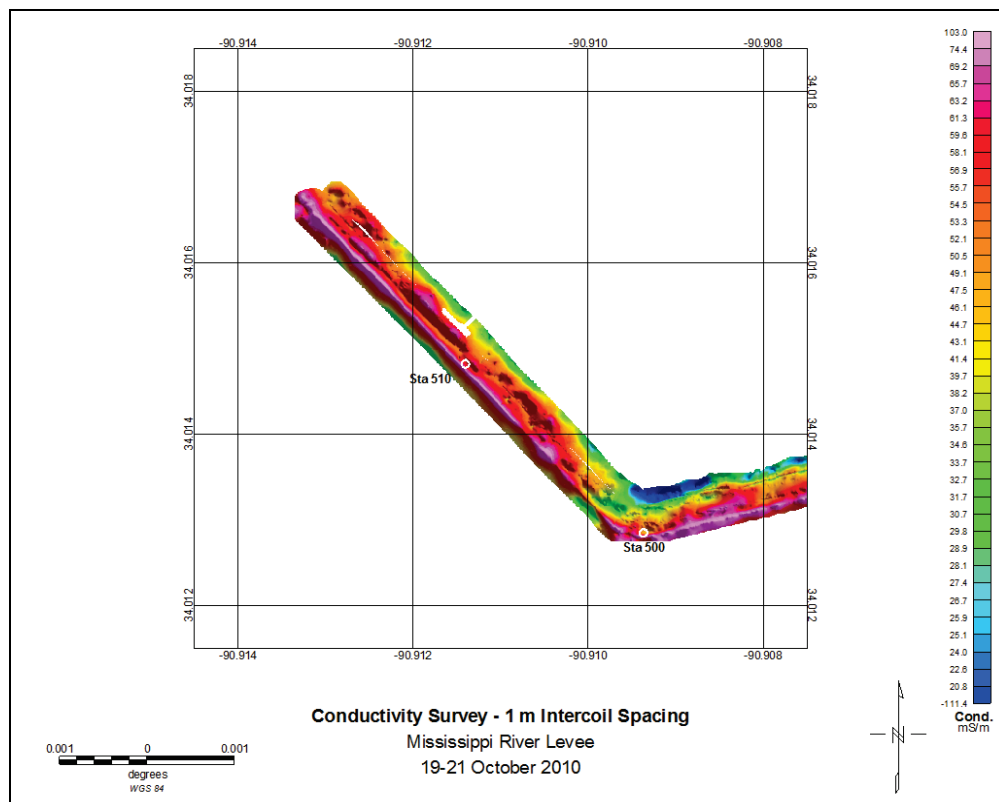


Figure 11. EM38 conductivity survey results, western portion, Mississippi River levee, Cleveland, MS.

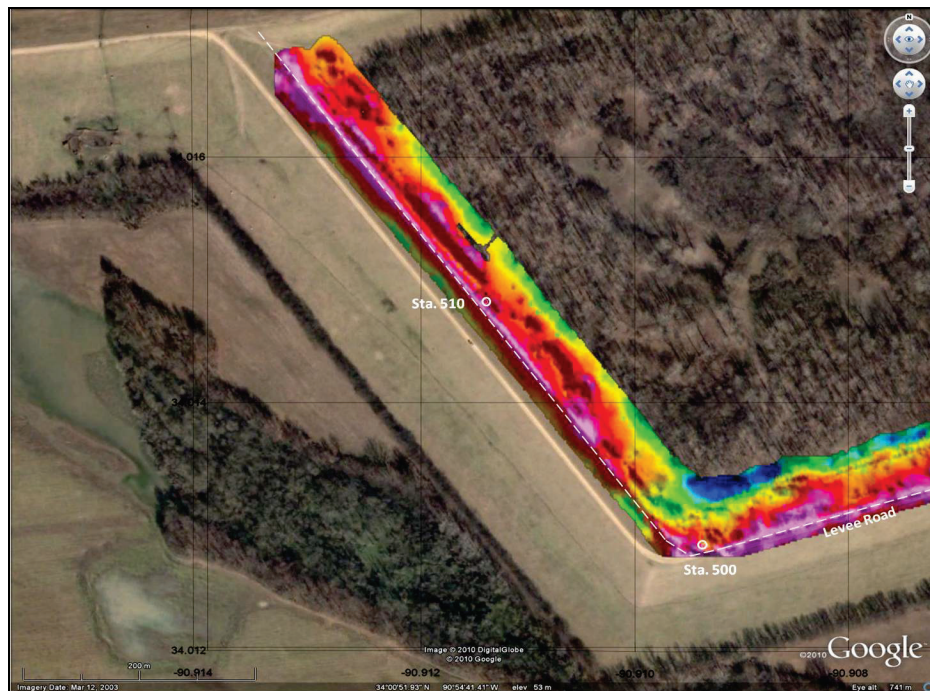


Figure 12. EM38 conductivity survey results, western portion, overlaid on Google Earth imagery, Mississippi River levee, Cleveland, MS.

The two relatively high conductivity anomalous areas shown in the eastern portion of the survey area (Figures 7 and 8) are associated with what appear to be two possible incipient slides. Figure 13 shows the ground disturbance found at the location of anomaly 1.



Figure 13. View of anomaly 1. (A) view looking upslope (southeast), (B) view looking upslope (south), (C) view looking across the slope (southwest), (D) close-up view of scarp.

ADDITIONAL INFORMATION: This technical note was prepared by Dr. Joseph B. Dunbar and Dr. Maureen K. Corcoran, U.S. Army Engineer Research and Development Center-Geotechnical and Structures Laboratory (ERDC-GSL). The study was conducted under the Flood and Coastal Storm Damage Reduction Program. This technical note should be cited as follows:

Dunbar, J.B., and M. K. Corcoran. 2014. *Electromagnetic induction survey of the Mississippi River in Cleveland, Mississippi*. ERDC/GSL TN-14-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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